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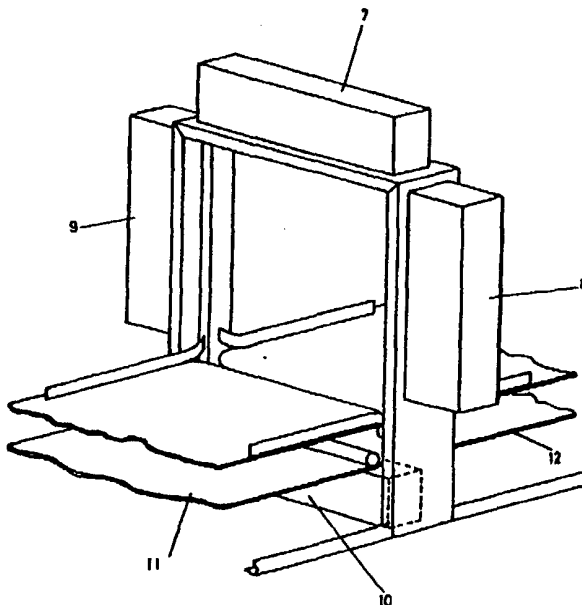
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G1A  
Selected US specifications from IPC sub-class G01B

(54) Optoelectronic measurement  
of package volume

(57) To measure the volume of an arbitrarily shaped three-dimensional object, the object is passed through a scanning plane on conveying means 11, 12 and the respective dimensions of the object in two perpendicular measurement directions in the scanning plane are measured at intervals during the passage of the object through the scanning plane by two electro-optical systems 8, 9 and 7, 10. Means are provided for calculating the cubical volume of the object by determining the area of a rectangle of minimum area that fits around the profile in one measurement plane and multiplying the area of the minimum rectangle by the maximum dimension of the object perpendicular to the one measurement plane obtained from the profile in the other measurement plane.

FIGURE 3



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covered. The minimum rectangular area resulting from this procedure is taken as the best fit and multiplied by the package height to give the cubical volume. To shorten the computation time involved in this iterative process, the number of points defining the profile is reduced to a relatively small number by an algorithm which removes points lying on any concave sections of the profile. The ends of each concave section are then joined up by notional straight lines. In this way a profile defined by several thousand points can be represented by a polygon of typically ten to twenty points.

The procedures described in the above two paragraphs are shown in block diagram form in Fig. 5.

The configuration shown in Fig. 1 is limited in the size of package it can accept by the physical size of lenses that it is possible to manufacture. Lenses 2 and 3 may be made of glass or, preferably, moulded plastic in the form of Fresnel lenses which allow diameters up to 250 mm or greater.

An embodiment of the invention will now be described which can deal with much larger packages. The description refers to the accompanying Figs. 2 and 3.

The limitation of the field of view imposed by a single optical system can be overcome by stacking a plurality of systems side by side, each with its own individual scanned array and light source. Fig. 2 shows schematically such an arrangement using a stack of four identical optical modules for each cross-sectional view capable of accepting packages up to 1.1 metre square. In each system lens 4 and array 5 are combined together in a linescan camera 6. Alternate modules are displaced, or staggered, perpendicular to the plane of Fig. 2 to allow individual camera fields of view to overlap slightly. The correspondingly displaced image data obtained when a package passes through the measuring plane is corrected for in the subsequent image processing.

Fig. 3 illustrates in outline an engineered embodiment of the multiple camera scanning system of Fig. 2. The light sources and collimating lenses are contained in illuminator housings 7 and 8, and the cameras and de-collimating lenses in camera housings 9 and 10. These four housings are rigidly fastened together on a framework through which runs a conveyor system 11 and 12, which is split to allow the vertically scanning beams to pass between the illuminator housing 7 and camera housing 10. Packages are transported along the conveyor and scanned vertically and horizontally as they cross this gap. Longitudinal position information is derived from an encoder driven by the conveyor. The two halves of the conveyor system, 11 and 12 are mechanically coupled together so that they both run at the same speed.

Fig. 4 shows, in block diagram form, the components of a total volume measuring equipment incorporating the scanner of Fig. 3 and also an in-line electronic weighing platform feeding package weights to the system computer. This facility allows the machine to distinguish which packages should be charged according to weight and which should be charged according to volume, and also to calculate volumetric equivalent weight.

#### CLAIMS

1. A method of measuring the volume of an arbitrarily shaped three-dimensional object, comprising passing the object through a scanning plane, measuring the respective dimensions of the object in two non-parallel measurement directions in the scanning plane at intervals during the passage of the object through the scanning plane to provide respective profiles of the object in respective measurement planes and calculating the cubical volume of the object by determining the area of a rectangle of minimum area that fits around the profile in one measurement plane and multiplying the area of the minimum rectangle by the maximum dimension of the object perpendicular to the one measurement plane obtained from the profile in the other measurement plane.

2. A method according to Claim 1, comprising calculating the actual volume of the object by using pairs of corresponding measured dimensions to determine the volume of a corresponding elementary slice of the object parallel to the scanning plane and summing the volumes of the elementary slices to obtain the total actual volume.

3. A method according to claim 1 or 2, wherein the object is passed through the scanning plane at a uniform speed.

4. A method according to any one of claims 1 to 3, in which the two measurement directions are perpendicular.

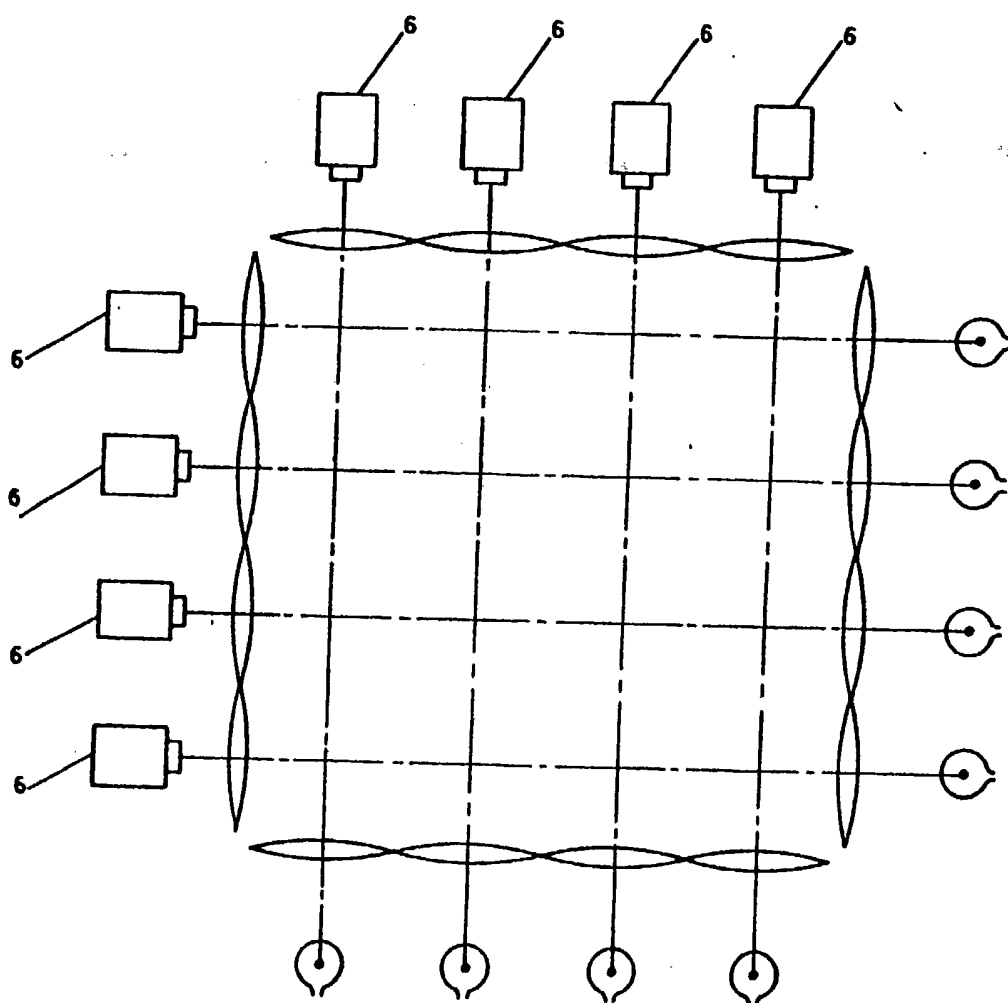
5. Apparatus for measuring the volume of an arbitrarily shaped three-dimensional object, comprising means for passing the object through a scanning plane, means for measuring the respective dimensions of the object in two non-parallel measurement directions in the scanning plane at intervals during the passage of the object through the scanning plane to provide respective profiles of the object in respective measurement planes, and means for calculating the cubical volume of the object by determining the area of a rectangle of minimum area that fits around the profile in one measurement plane and multiplying the area of the minimum rectangle by the maximum dimension of the object perpendicular to the one measurement plane obtained from the profile in the other measurement plane.

6. Apparatus according to Claim 5, comprising means for calculating the actual volume of the object by using pairs of corresponding



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FIGURE 2 D F A

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